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Integrating criminological and mental health perspectives on low self-control: A multi-domain analysis

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ABSTRACT

Purpose: Criminological theories of crime, delinquency, and deviancy emphasize the causal role of low self-control whereas models of psychopathology posit a general trait liability, "disinhibition", contributing to persistent antisocial behavior and substance use. The aim of the current work was to link these compatible perspectives on deviancy through reference to a biobehavioral conceptualization of disinhibition.

Methods: We examined how the Grasmick et al. (1993) self-control scale, relates to (a) trait disinhibition as indexed by self-report scales, performance on inhibitory-control tasks, and brain reactivity to cognitive stimuli, and (b) a cross-domain index combining measures from these three domains.

Results: As expected, variation in self-control was robustly associated with antisocial deviance, substance use problems, and measures of disinhibition across measurement domains. Further, a factor analytic model provided compelling evidence that the Grasmick et al. scale operates as a robust indicator within a biobehavioral conceptualization of disinhibition.

Conclusions: Findings confirm a strong link between self-control and trait disinhibition, and support the view that deficits in self-control have a prominent biobehavioral basis. Research in the areas of criminology and psychopathology can mutually benefit from a focus on influences contributing to variations in self-control, conceptualized as trait disinhibition.

1. Introduction

In *A General Theory of Crime,* Gottfredson and Hirschi (1990) proposed that low self-control, a dispositional trait reflecting tendencies to disregard long-term consequences of one's action, plays a central and causal role in the development of criminal behavior. In response to this prominent theoretical model, a compelling body of scientific evidence from the criminology field has emerged in support of a self-control theory of crime and delinquency. Parallel developments in research within the fields of clinical psychology and psychiatry have identified a similar construct, termed externalizing proneness or trait disinhibition, underlying psychological disorders marked by behavioral deviancy in the forms of substance use, aggression, and chronic criminality. Both self-control and disinhibition constructs have been found to be highly heritable, suggesting links to genetically mediated neurobehavioral systems, and efforts have been made to connect the constructs of disinhibition (cf. Patrick, Venables et al., 2013; Venables, Foell, et al., 2017) and self-control (Reynolds & McCrea, 2017) to neural systems reflecting inhibitory processes. However, there has been little systematic work directly examining the interface between these two independently developed and compatible perspectives on delinquency. The current study sought to empirically integrate these distinct yet complementary lines of inquiry and demonstrate that criminological perspectives on low self-control can be situated within a broader framework (i.e., a biobehavioral model of inhibition-disinhibition) that spans multiple measurement domains (self-report, cognitive task-performance, and neurophysiology) and effectively predicts criminal (antisocial) behavior and affiliated problems such as substance use.

1.1. Criminological perspectives on delinquency: low self-control

Building upon earlier writings on personality and criminality (McCord & McCord, 1959; Nye, 1958), Gottfredson and Hirschi (1990) proposed that low self-control was an essential person-centric construct

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that contributes to engagement in criminal activity. Specifically, these investigators proposed that low self-control interacts with criminal opportunity to result in the commission of acts of "force and fraud." Since their proposed theory, a large body of research has accrued testing its central tenants. One critical advance in this line of research was the development of a self-report inventory for assessing low self-control by Grasmick et al. (1993). Utilizing an iterative approach to test construction, Grasmick et al. created test items designed to operationalize six theoretically interrelated components described in Gottfredson and Hirschi's writings on the nature of the self-control construct consisting of impulsivity, preference for simple over complex tasks, risk seeking, preference for physical rather than cerebral activities, self-centered orientation, and angry volatility linked to low tolerance for frustration (see Grasmick et al., p.13). Importantly for the construct validity of self-control, largely the same content coverage has been described independently by other investigators (Barlow, 1991). The Grasmick et al. Self-Control scale consists of 24 items, four indexing each of the 6 content facets. Factor analytic work on the structure of the Grasmick Self-Control inventory has provided support for the structural validity of the six facet scales of the inventory, showing that each index a coherent dimension and that all load onto a higher-order factor interpretable as reversed self-control (Arneklev, Grasmick, & Bursik, 1999). These findings suggested that (low) self-control can be conceptualized as an individual-difference attribute entailing poor behavioral regulation manifested in multiple life domains.

Supporting Gottfredson and Hirschi's theory, low scores on the Grasmick et al. inventory have been shown to interact with criminal opportunity to predict criminal behaviors (e.g., Hay & Forest, 2008). Additionally, low self-control scores predict level of criminal opportunity, indicating that low self-control affects the extent to which individuals enter into situations of risk for illegal behavior (Longshore & Turner, 1998). Expanding upon self-control theory, Longshore, Rand, & Stein (1996) demonstrated a unitary factor structure and similar predictive utility of the Grasmick et al. Self-Control scale in a sample of offenders with more serious charges. However, it should be noted that the unidimensional nature of the Grasmick et al. Self-Control scale has not always been replicated across samples. DeLisi, Hochstetler, and Murphy (2003), for instance, failed to replicate the single-factor structure of the inventory in a sample of male offenders. Additionally, a limited amount of research has been conducted to examine the external correlates and predictive associations of the facet-level scales of the Grasmick et al. inventory.

Since the initial empirical investigations, a number of subsequent studies have found that low self-control is associated with criminal behavior and contact with law enforcement (Beaver, DeLisi, Mears, & Stewart, 2009; DeLisi & Vaughn, 2008; DeLisi, Beaver, Wright, & Vaughn, 2008). Two large scale meta-analytic reviews of research using the Gramick et al. inventory concluded that this instrument was linked with criminal behavior in both cross-sectional (Pratt & Cullen, 2000) and longitudinal investigations (Vazsonyi, Mikuška, & Kelley, 2017).

Taken as a whole, research findings over the decades since Gottfredson and Hirschi published *A General Theory of Crime* have provided consistent support for the notion that low self-control is a key individual trait characteristic that is associated with higher likelihood of crime commission, regardless of environmental opportunities for crime. These findings underscore the importance of developing a nuanced understanding of low self-control for elucidating the etiology of criminal behavior and advancing efforts towards preventing it.

1.1.1. *Causal bases of self-control*

One major hypothesis of Gottfredson and Hirschi's theory was that low self-control arises from poor socialization in the home environment. This claim is in contrast with other theorists who have suggested that individual differences in self-control, like other temperament characteristics, are rooted to an appreciable degree in biological or biobehavioral systems (Barkley, 1997; Beaver, Wright, & DeLisi, 2007; Harris, 1998). As a whole, contemporary empirical evidence favors the view that biobehavioral and psychosocial factors contribute jointly to crime proneness, over Gottfredson and Hirschi's view that low self-control arises primarily due to environmental mechanisms (Wright & Beaver, 2005). In particular, research has consistently demonstrated that at least some of the variance in self-control, particularly that which overlaps with criminality, is attributable to genetic influences (Connolly & Beaver, 2014).

These lines of evidence point to genetically based variation in the functioning of basic biobehavioral systems as an important mechanism for self-control deficits that confer risk for criminal deviancy. As discussed in the next section below, this perspective dovetails with psychological evidence for a strongly heritable trait-liability factor underlying clinical disorders involving impulsive-antisocial behavior and addictive tendencies.

1.2. *Psychological constructs relevant to criminal deviancy: Externalizing and trait disinhibition*

Investigative work by psychological and psychiatric researchers has demonstrated broad dispositional factors underlying prevalent forms of psychopathology. Krueger (1999), for example, analyzed patterns of covariance among common psychological disorders in a large epidemiological sample and found that antisocial deviance (chronic delinquency beginning in childhood) and substance use problems share a common latent factor termed *externalizing*, a finding that has been replicated in several other studies (e.g., Slade & Watson, 2006; Vollebergh et al., 2001). A major implication of demonstrating a common underlying factor is that disorders of these types likely arise from partially overlapping etiological sources. Krueger et al. (2002) extended this work by demonstrating that scores on a broad personality dimension akin to Gottfredson and Hirschi's self-control, termed Constraint, operated as a robust indicator of the latent externalizing factor – indicating a dispositional quality to this common factor. Biometric modeling in this sample of twins identified a highly heritable externalizing factor that accounted for covariance among child and adult antisocial behavior, dependence on alcohol and other substances, and Constraint-related personality traits (Krueger et al., 2002). Results from this study provide direct evidence for a largely genetically-based trait factor that confers risk for externalizing problems of various types including antisocial deviance.

Building on the foregoing findings, Krueger et al. (2007) developed a formal assessment model for this clinical problem domain in the form of a multi-scale questionnaire measure, the Externalizing Spectrum Inventory (ESI; see also Patrick, Kramer, et al., 2013). The ESI includes 23 subscales for measuring externalizing problems of various types including rule-breaking, reckless risk-taking, and differing forms of aggression and substance abuse, along with affiliated personality traits. Exploratory and confirmatory factor analyses of scores on these 23 ESI subscales indicated the presence of a common underlying factor, termed *general disinhibition*, on which all subscales loaded – along with distinguishable callous-aggression and substance-abuse factors on which certain scales loaded concurrently. Subscales that operated as exclusive indicators of the general disinhibition factor were mainly indicative of trait dispositions (impulsiveness, irresponsibility, boredom proneness, blame externalization), along with a smaller number tapping specific deviant-behavioral tendencies (e.g., thievery, fraudulence). Consistent with work demonstrating strong heritability for the common factor underlying externalizing disorder diagnoses (Krueger et al., 2002), Yancey et al. (2013) demonstrated in an adult twin sample that scores on a 30-item scale measure of the ESI's general disinhibition factor were highly heritable, and covaried substantially with clinically assessed externalizing symptoms, primarily as a function of genetic influences in common between the two.

In common with findings in the empirical-criminological literature, contemporary findings in the psychopathology research literature have identified a heritable dispositional factor reflecting tendencies towards boredom, impulsiveness, irresponsibility, and externalizing of blame that contributes substantially to behavioral deviance in forms including theft, aggressiveness, fraud and deceitfulness, and abuse of differing substances. These commonalities pose two important questions:

1) Do scale measures of self-control (Grasmick et al., 1993) and trait disinhibition (Krueger et al., 2007; Patrick, Kramer, et al., 2013) index the same underlying dispositional construct?
2) If scales of the two types indeed measure the same dispositional dimension, then what biobehavioral systems/processes underlie variation along this dimension?

1.3. Conceptualizing low self-control and disinhibition in neurobehavioral terms

As described above, twin-modeling analyses of externalizing problems and related traits have demonstrated that the common factor underlying this clinical domain is highly heritable (~80%; Krueger et al., 2002; Young et al., 2000) and can be viewed as a general trait liability for impulsive behavioral deviancy. Parallel research in the criminology literature has shown that genetic factors account for substantial variance in the association between low self-control and criminal offending (Beaver, DeLisi, Vaughn, & Wright, 2008). Given this evidence indicating a strong biological-genetic basis for these two constructs – self-control and externalizing proneness – it becomes important to evaluate their association and consider what brain systems and neuropsychological processes are associated with variation in measures of these constructs.

The best-established neurophysiological correlate of externalizing proneness is reduced amplitude of the P3 response—a positive brain potential, maximal over parietal scalp regions, that follows the occurrence of rare or otherwise salient stimuli within a sequence. Reduced oddball-P3 amplitude, assessed most commonly in relation to infrequent target stimuli (generally comprising 10–20% of task trials) within an 'oddball task', has been observed in relation to various specific impulse control problems (Iacono, Malone, & McGue, 2008), and is also associated with risk for the subsequent development of such problems (Begleiter, Porjesz, Bihari, & Kissin, 1984; Iacono et al., 2002). The P3 brain potential response is hypothesized to reflect cortical activation associated with frontal-attentional and working memory (context updating) processes, to differing degrees depending on task characteristics and in relation to clinical/dispositional individual-difference characteristics (Polich, 2007). Extending these observations, lower amplitude of the P3 brain potential response operates as an indicator of the general factor of externalizing psychopathology (Patrick et al., 2006), and subsequent work has shown that the association between this general externalizing factor and P3 reflects overlapping genetic influences (Hicks et al., 2007). Recent work has demonstrated that a scale measure of trait disinhibition composed of items from the ESI also relates to reduced P3 brain response as a function of variance in common with the externalizing psychopathology factor (Yancey et al., 2013). Importantly, other work has demonstrated that variants of P3 from non-oddball tasks covary with oddball-target P3 and load together with self-report assessed trait disinhibition onto a common factor (Nelson et al., 2011; Patrick, Venables, et al., 2013). As such, P3 brain responses from differing tasks and experimental conditions can be combined with questionnaire-assessed externalizing proneness to form a neurobehavioral index of trait disinhibition.

In the domain of behavioral performance, self-control can be conceptualized as the capacity to guide motoric responses on the basis of internal cognitive representations and affective motivational systems. For example, research by Miyake and colleagues has shown that a range of cognitive performance tasks indexing working memory, response inhibition, and set shifting systematically covary, such that they load onto a common 'executive function' factor (Miyake & Friedman, 2012). Inhibitory control tasks are one class of executive function task procedures that load directly onto a higher-order executive function factor, with set-shifting and working memory task measures also contributing to respective sub-factors (Miyake & Friedman, 2012). Three response inhibition tasks that operate as effective inhibitory control indicators of this common executive function factor includes the Stroop interference, ocular-antisaccade, and stop signal tasks (Miyake et al., 2000). Using these three tasks to index executive function in a sample of adolescent monozygotic and dizygotic twin pairs, Young et al. (2009) found that variation along this cognitive dimension covaried systematically and negatively with scores on the externalizing psychopathology factor (quantified using symptom scores for childhood externalizing problems along with a scale measure of impulsive risk-taking tendencies)—and this association was shown to be substantially attributable to common genetic influences. The results shed important light as to the cognitive-psychological mechanisms implicated in externalizing and trait disinhibition. In the context of the aforementioned research, these findings suggest that task measures of executive functioning operate as indicators of the general liability for externalizing problems (i.e., disinhibition) along with relevant trait-scale measures and variants of P3 brain response.

1.4. Current study aims and hypotheses

The converging lines of literature described in the foregoing sections suggest that, despite differing conceptual-empirical origins, the concepts of low self-control emphasized in the criminology literature and of disinhibition from the clinical-psychological literature largely describe the same underlying construct. The primary aim of the current study was to demonstrate that low self-control is represented within a cross-domain nomological network of disinhibition. We have previously described a cross-domain model of disinhibition (Venables, Foell, et al., 2017; Venables, 2016) in which domain specific lower-order factors (self-report, task performance, and brain response) cohered to form a higher-order *cross-domain* factor that was associated with different forms of delinquency (e.g., antisocial/criminal behavior and substance use). In the present study, we sought to integrate self-control with this conceptual and empirical model of disinhibition that spans multiple domains (or levels) of analysis. The specific hypotheses described below were tested to empirically bridge these differing perspectives on criminal/delinquent behavior.

Our overarching goal for the manuscript was to demonstrate that low self-control as indexed by the Grasmick et al. scale is centrally situated within this multi-domain, biobehavioral model of inhibitory control. Based on prior work as reviewed above, specific hypotheses of the current study were as follows:

(1) Low self-control, as operationalized by the Grasmick et al. (1993) scale, would be robustly correlated with self-report measures of disinhibition and with specific acts of impulsive-behavioral deviancy (i.e., antisocial behavior and substance abuse);
(2) Low self-control would show associations with previously established task-behavioral and brain-response indicators of trait disinhibition, and correlate robustly with a cross-domain factor reflecting covariance among indicators of trait disinhibition from these two domains and the domain of self-report;
(3) Lastly, we expanded our empirical cross-domain model of disinhibition and predicted that low self-control would be a robust indicator in the model.

2. Method

2.1. Participants

Study participants were 149 undergraduate students and general-community adults who met the following inclusionary criteria: no current major mental disorder (i.e., schizophrenia, bipolar I) as determined from questions pertaining to mental health history on a brief pre-test questionnaire; competency in English; and lack of visual or hearing impairments. Participants were recruited via online postings available to undergraduate students and an online forum (craigslist) also available for general community members. Following procedures used in prior research (e.g., Hall et al., 2007; Patrick, Venables, et al., 2013), individuals were pre-selected using a 20-item scale measure of disinhibitory tendencies to ensure representation of high and low scorers (top and bottom 15%, respectively, from a larger screening sample) along with representation of intermediate scorers. Participants indicated willingness to be contacted for lab testing in the pre-screening assessment. The mean age of study participants, of whom 43% were female, was 20.5 (*SD* = 3.8). The racial/ethnic composition of the sample was: 69.1% Caucasian, 12.8% African American, 12.1% Hispanic, 1.3% Asian, and 4.7% other, mixed race, or unreported. Procedures for the study were approved by the Institutional Review Board of Florida State University and all participants provided informed written consent prior to both the questionnaire screening assessment and the lab testing session. Student participants were compensated with course credit and/or $15 per hour and community participants received $15/h as compensation.

2.2. Grasmick et al. self-control scale

The Grasmick et al. Self-Control scale (Grasmick, Tittle, Bursik, & Arneklev, 1993) is a 24-item scale designed to assess dispositional attributes of (low) self-control hypothesized by Gottfredson and Hirschi (1990) to contribute to delinquent and criminal behaviors. Items were answered using a 4-point scale as to *how well the particular statement applies to you*, with response options of *strongly agree, agree somewhat, disagree somewhat,* and *strongly disagree.* Scores from this measure were coded with larger values reflecting greater self-control. We computed total scores (internal consistency Cronbach's α = 0.87) along with six subscale scores (Impulsivity α = 0.72; Simple Tasks α = 0.70; Risk Seeking α = 0.86; Physical Activities α = 0.76; Self-Centeredness α = 0.80; Temper α = 0.78).

2.3. Cross-domain measures of disinhibition

A detailed description of the trait disinhibition measures included in the present study, including task procedures and derivation of dependent measures and their psychometric properties, are available from the authors on request and elsewhere (Venables, Foell, et al., 2017; Venables, 2016). The following is a brief description of self-report, task performance, and brain response indicators used to quantify disinhibition across differing biobehavioral assessment modalities:

2.3.1. Psychometric measures of self-reported disinhibition

Four self-report scales were used as psychometric measures of disinhibition, assessing general dispositional aspects of this construct (i.e., tendencies towards unreliable and impulsive behavior in various contexts across time): (1) The 20-item ESI-DIS scale, from the Externalizing Spectrum Inventory Brief Form (ESI-BF; Patrick, Kramer, Krueger, & Markon, 2013; items answered using a 4-point scale, with response options of *True*, *somewhat true*, *somewhat false*, and *False*); (2) A scale consisting of 18 *true/false* items from the brief form of the Multidimensional Personality Questionnaire (MPQ-bf; Patrick, Curtin, & Tellegen, 2002), selected to index disinhibitory tendencies on the basis of content-relevance and psychometric properties (MPQ-DIS scale; Brislin et al., 2015, 2017); (3) A scale consisting of 19 items with response options of *True*, *somewhat true*, *somewhat false*, and *False* from the Psychopathic Personality Inventory (PPI; Lilienfeld & Andrews, 1996), also selected to index disinhibitory tendencies (PPI-DIS scale; Hall et al. 2014); (4) The Socialization Scale (SO; Gough, 1960), a 54 *true/false* item measure, with lower scores reflecting impulsive-antisocial tendencies known to correlate with general disinhibitory tendencies as assessed by the ESI (Hall et al., 2007).

2.3.2. Inhibitory control task performance measures of disinhibition

Behavioral performance measures of disinhibition were derived from lab-based inhibitory control tasks similar to those used in prior studies to assess individual differences in executive function (Miyake et al., 2000; Miyake & Friedman, 2012; Young et al., 2009) or attentional control (McVay & Kane, 2009, 2012). In brief (details provided elsewhere; Venables, Foell, et al., 2017; Venables, 2016), participants first completed the Antisaccade task (Hallett, 1978), an oculomotor task that measures the ability to suppress prepotent responding by requiring the inhibition of reflexive eye movement towards a visual distracter in order to correctly identify a co-occurring target stimulus. Target identification accuracy during the Antisaccade task (proportion of correct responses from 0 to 1) was the primary dependent measure. Participants then completed a Stop Signal task (Verbuggen & Logan, 2008) that began with an initial block of target trials (simple geometric shapes) to assess reaction time at baseline, followed by blocks of trials in which participants were signaled at times (25% of trials) to inhibit their response to task stimuli by an auditory cue occurring after target stimulus onset. The stop signal delay (time between target onset and auditory cue) was varied based on accuracy for the preceding stop trial. Performance on the Stop Signal task was quantified using a measure of proactive inhibition (mean reaction time for “go” trials of main task minus mean reaction time for initial baseline block; cf. Verbuggen & Logan, 2009). Participants next completed a variant of the Stroop interference task (Stroop, 1935) in which they indicated via button presses the stimulus color of asterisk strings and color words that appeared in four different font colors. Reaction time to incongruent word-font color trials was the performance measure from the Stoop task. Lastly, participants were administered the Sustained Attention to Response Task (SART; McVay & Kane, 2009, 2012), a variant of the Go/No-Go task commonly used to measure attentional/inhibitory control. Consistent with many previous studies (e.g. Braver, Barch, Gray, Molfese, & Snyder, 2001; Garavan, Ross, & Stein, 1999), the “Go” stimulus occurred more frequently (89% of trials) than the “No-Go” stimulus (remaining 11% of trials), establishing a prepotent response set that required recruitment of inhibitory control to override. Reaction time variability (within-subject RT *SD* to “Go” trials) scores were computed from this task.

2.3.3. Task procedures for neurophysiological measures of disinhibition

Participants completed three cognitive task procedures in which P3 brain response was measured to provide neurophysiological indicators of inhibition-disinhibition; details of these procedures are reported elsewhere (Venables, Foell, et al., 2017; Venables, 2016). Specifically, variants of the P3 response were derived from; (1) a modified, 3-stimulus version of the ‘rotated-heads’ visual oddball task (Begleiter et al., 1984) in which picture stimuli are included as novel stimuli (see also Venables et al., 2011, 2017, for details); (2) an ‘arrow’ version of the flanker task (Eriksen & Eriksen, 1974), administered in a manner consistent with previous investigations (e.g., Weinberg et al., 2015); and (3) a pseudo-gambling (choice-feedback) task used in a number of prior published studies (Bress, Smith, Foti, Klein, & Hajcak, 2012; Foti & Hajcak, 2009).

Procedures for recording of electroencephalographic (EEG) activity, processing of the EEG data, and derivation of event-related potential (ERP) measures followed our prior published work (Patrick, Venables, et al., 2013, Venables et al., 2011, 2017; Yancey et al., 2013); details specific to the current study are provided elsewhere (Venables, Foell, et al., 2017; Venables, 2016). The neurophysiological measures of disinhibition in the reported analyses consisted of: P3 response to target stimuli in the novelty-oddball task, measured at the midline parietal (Pz) scalp site; P3 response to target stimuli and error-P3 (P3e) following incorrect responses in the arrow-flanker task, assessed at midline parietal (Pz) and midline frontocentral (FCz) scalp sites, respectively; and P3 response to feedback stimuli in the pseudo-gambling task, measured at the centroparietal (CPz) scalp site.

2.4. Delinquency measures

Questionnaire-based measures of antisocial behavior and substance use were administered as delinquency criterion measures for evaluating associations with self-control and disinhibition. In addition to the self-report scales included as measures of general dispositional tendencies, the following scales were administered to study participants as criterion measures assessing specific deviant behavioral acts:

The *Behavior Report on Rule-Breaking* (BHR; Hall et al., 2007), a 33-item self-report inventory, assesses for past instances of antisocial behaviors in adolescence (prior to graduating high school or age 18) and adulthood (after high school or age 18). Items were answered using a 4-point scale as to *how often you broke each rule*, with response options of *never, once or twice, several times,* and *very often.* Internal consistency reliabilities (Cronbach's alpha) in the current sample were $\alpha = 0.89$ for the Juvenile subscale and $\alpha = 0.83$ for the Adult subscale.

The *Crime and Analogous Behavior Scale* (CAB; Miller & Lynam, 2003) is a 55-item self-report inventory that assesses for antisocial behaviors and also substance abuse history; an abbreviated 16-item version was used in the current study. Questions on the CAB ask *have you ever* engaged in specific behaviors (e.g., *"Have you taken something not belonging to you worth over $50?"*), and are answered "*yes*" or "*no*". Reliabilities (α) for the two subscales of this brief-form CAB (Antisocial Behavior = 9 items; Substance Abuse = 7 items) in the current study were 0.60 and 0.71, respectively.

The *ESI-BF Substance Abuse scales* (Patrick, Kramer, et al., 2013) are abbreviated versions of six facet scales from the Externalizing Spectrum Inventory (Krueger et al., 2007) that assess for lifetime history and current use of three types of substances (alcohol, marijuana, other drugs) and problems experienced in relation to each; αs for these scales in the current sample ranged from 0.76 to 0.91 (median $\alpha = 0.87$).

Along with analyses focusing on these specific delinquency scales, we also evaluated effects for the following criterion-variable composites: (1) an Antisocial Behavior Composite, computed as the average of standardized scores for the BHR Adolescent and Adult scales along with the CAB Antisocial scale; (2) an ESI Substance composite, computed as the average of standardized scores for the six ESI substance abuse scales; and (3) an Externalizing Composite, combining standardized scores for the BHR juvenile and adult scales with standardized scores for the ESI Substance composite. This latter composite was created to index the general dimension of psychopathology revealed by factor analytic work on the structure of externalizing problems of various types (cf. Krueger, 1999).

2.5. Study procedure

Enrolled study participants first completed the battery of inhibitory control cognitive task procedures in the following order: Antisaccade, Stop Signal, Stroop, and SART (Go No-Go). Next, following the placement of electrophysiological recording sensors, participants completed the flanker, novelty-oddball, and the choice-feedback pseudo-gambling tasks. Some of the questionnaire-scale measures were administered between task procedures to provide a break from cognitive testing, with the remainder completed at the end of the testing session prior to study debriefing. All study participants completed the assessment battery in the same sequence.

2.6. Analytic plan

Zero-order correlations were first computed to test for associations between total and subscale scores of the Grasmick et al. inventory with biobehavioral indicators of trait disinhibition and delinquency measures (self-reported antisocial behavior and substance abuse). As described in previous work with this sample (Venables, Foell, et al., 2017; Venables, 2016), trait disinhibition scores were computed as estimated factor scores corresponding to a higher-order confirmatory factor analytic (CFA) model. The resultant model included three lower-order factors that were defined by indicators from the three distinctive measurement domains (self-report, task performance, and brain response), which in turn, were each specified to load onto a general *cross-domain* factor that captured the shared variance across domain-specific operationalizations of disinhibition. In addition to scores from this CFA model, we also included ESI-DIS scores to demonstrate associations for this brief measure with self-control. CFA analyses were performed using *Mplus* (version 7.3; Muthén & Muthén, 1998–2015), with full-information maximum likelihood estimation to accommodate missing data for individual indicators, allowing for estimation of factor scores for all participants ($n = 149$).

Next, to further test for the fit of self-control within a biobehavioral nomological network of disinhibition, the aforementioned higher-order CFA model was recomputed with Grasmick et al. self-control total scores included as an additional indicator of the self-report disinhibition factor, with the task performance and brain response factors remaining unchanged. Absolute fit was assessed using the traditional chi-square (χ^2) method, which yields lower values for better fitting-models, and (given notable limitations of χ^2; Hu & Bentler, 1999) using other fit indices as follows: root-mean-square error of approximation (RMSEA), standardized root-mean-square residual (SRMR), and Comparative Fit Index (CFI). For RMSEA and SRMR, values below 0.05 indicate good fit, values from 0.05 to 0.08 indicate moderate fit, and values above 0.08 indicate inadequate fit; for CFI, values of 0.95 or higher indicate good fit (Hu & Bentler, 1999).

3. Results

3.1. Associations between self-control, biobehavioral measures of disinhibition, and delinquency

Table 1 presents zero-order correlations for associations between Grasmick et al. Self-Control total and subscale scores with trait disinhibition (ESI-DIS along with self-report, inhibitory control task performance, brain response, and cross-domain estimated factor scores) and measures of antisocial behavior and substance abuse. As predicted, Self-Control total scores were robustly (negatively) associated with self-reported disinhibition ($rs > -0.61$), antisocial behavior ($rs = -0.23$ to -0.51), substance use ($rs = -0.32$ to -0.50), and the externalizing composite. Additionally, Self-Control total scores were significantly correlated with disinhibition when assessed by the behavioral task-performances factor, neurophysiological (brain response) factor, and the cross-domain index of disinhibition reflecting a *biobehavioral* operationalization spanning multiple measurement domains. As expected (cf. Patrick, Venables, et al., 2013), the magnitude of associations between self-control scores assessed via self-report and lab-task measures of disinhibition were smaller (~ 0.25) as compared to magnitudes observed for self-reported disinhibition (~ 0.6). However, this was notably enhanced ($r = -0.39$) for the cross-domain score that includes covariance between lab-task data with self-reported experiences of disinhibitory tendencies.[1]

[1] Results from supplemental regression analyses incorporating total scores from the Grasmick et al. scale along with ESI-DIS scores demonstrated that predictive relations for self-control with delinquency criterion measures were attributable to the Grasmick et al. scale's overlap with self-report disinhibition. Grasmick et al. Self-Control total scores were entered as a predictor in the first step of separate models for the antisocial behavior and substance use composites. Next, ESI-DIS was entered in the second step to test a) the degree to which ESI-DIS accounted for the observed associations between Self-Control and these delinquency measures, and b) if ESI-DIS predicted incrementally over the Self-Control scale. For the antisocial behavior composite, Self-Control was a significant predictor in the first step ($B = -0.44, p < 0.001$) but was not significantly associated with

Table 1
Associations Between Grasmick et al. (1993) Self-Control Scales with Multi-Domain Measures of Disinhibition and Self-Reported Delinquency in the Forms of Antisocial Behavior and Substance Use.

Measure	Self-control Total	Impulsivity	Simple tasks	Risk seeking	Physical activity	Self-centered	Temper
Trait disinhibition							
ESI DIS-20	**−0.61**	**−0.66**	**−0.28**	**−0.51**	−0.19	**−0.32**	**−0.46**
Self-Report DIS	**−0.67**	**−0.71**	**−0.28**	**−0.52**	**−0.24**	**−0.38**	**−0.54**
Beh.-Performance DIS	**0.24**	**0.27**	0.17	0.10	0.05	0.10	**0.31**
Neurophysiology DIS	**0.26**	**0.29**	0.11	0.12	0.06	0.20	**0.28**
Cross-Domain DIS	**−0.39**	**−0.42**	−0.19	**−0.22**	−0.11	**−0.25**	**−0.39**
Antisocial behavior							
BHR Juvenile	**−0.51**	**−0.44**	−0.11	**−0.54**	−0.14	**−0.36**	**−0.37**
BHR adult	**−0.40**	**−0.37**	−0.07	**−0.47**	−0.14	**−0.27**	**−0.21**
CAB ASB	**−0.23**	−0.19	−0.06	**−0.30**	0.03	**−0.25**	**−0.30**
Antisocial Beh. Composite	**−0.43**	**−0.38**	−0.01	**−0.49**	−0.10	**−0.33**	**−0.33**
Substance use							
CAB substance use	**−0.37**	**−0.41**	−0.06	**−0.47**	−0.04	−0.14	**−0.27**
ESI Marijuana use	**−0.41**	**−0.38**	−0.08	**−0.49**	−0.11	**−0.24**	**−0.26**
ESI Marijuana problems	**−0.44**	**−0.46**	−0.14	**−0.51**	−0.15	**−0.22**	**−0.21**
ESI Drug Use	**−0.41**	**−0.43**	−0.07	**−0.52**	−0.05	**−0.22**	**−0.29**
ESI drug problems	**−0.32**	**−0.38**	−0.05	**−0.41**	−0.09	−0.09	−0.19
ESI alcohol use	**−0.41**	**−0.36**	−0.14	**−0.46**	−0.19	−0.15	**−0.24**
ESI alcohol problems	**−0.40**	**−0.43**	−0.16	**−0.36**	−0.18	−0.18	**−0.26**
ESI substance composite	**−0.50**	**−0.51**	−0.14	**−0.56**	−0.14	**−0.24**	**−0.31**
Externalizing composite	**−0.51**	**−0.48**	−0.11	**−0.57**	−0.15	**−0.32**	**−0.32**

Note. *Ns* = 146–149; Bolded coefficients $p \leq 0.01$; Self-Report DIS = estimated factor scores reflecting covariance among disinhibition self-report scales; Beh.-Performance DIS = estimated factors scores reflecting covariance among inhibitory-control behavioral performance measures, with lower scores corresponding to increased disinhibitory tendencies; Neurophysiology DIS = estimated factor scores reflecting covariance among P3 brain potential response measures with lower scores reflecting increased disinhibitory tendencies; Cross-Domain DIS = estimated factor scores reflecting shared variance across the three domain-specific inhibition-disinhibition factors; BHR = Behavior Report on Rule-Breaking; CAB = the Crime and Analogous Behavior Scale; ESI = Externalizing Spectrum Inventory brief form; Externalizing Composite = composite score reflecting shared variance among substance use and antisocial behavior externalizing problems.

In addition to results for total Self-Control scores, Table 1 also presents validity coefficients for the six subscales described by Grasmick et al. (1993). A parallel pattern of results was observed for the Impulsivity and Temper subscales as was seen for Total scores, though somewhat smaller in magnitude for the Temper scale. Notably, it was only these two subscales that were reliably associated with the behavioral performance and brain response disinhibition factors. By contrast, scores on the Risk Seeking subscale were not significantly correlated with the lab-task factors of disinhibition (though were associated with cross-domain scores); however, they were predictive of self-reported disinhibition along with antisocial behavior and substance use delinquency measures. Self-Centeredness subscale scores exhibited a comparable pattern of associations as was seen for Risk Seeking, with correlations less consistent for substance use scales. Lastly, the Simple Tasks and Physical Activities subscales were modestly associated with self-reported disinhibition ($rs = -0.18$ to -0.28); however, these two subscales exhibited limited validity evidence with regards to non-significant associations with lab-task measures of disinhibition and delinquency criteria.

3.2. Positioning low self-control within a cross-domain biobehavioral model of disinhibition

As previously described, our overarching goal in the present study was to demonstrate that low self-control can be considered part and parcel of a biobehavioral nomological network of trait disinhibition that conceptualizes this dimension in terms of variation in brain systems governing inhibitory control (executive function) processes. Towards this end, we computed the three-subfactor/one higher-order factor model described by Venables, Foell, et al. (2017), with the notable addition of Self-Control total scores as an additional indicator of the self-report domain factor (which loaded in turn on the higher-order cross-domain factor). Results from this model indicated that it fit the data well: χ^2 (62) = 78.31 [p = 0.079], RMSEA = 0.042 (90% confidence interval = 0.001, 0.068), SRMR = 0.058, CFI = 0.97. By comparison, the fit statistics for the cross-domain model that did not include the Grasmick et al. Self-Control scale (Venables, Foell, et al., 2017; Venables, 2016) were as follows: χ^2 (51) = 68.68 [p = 0.05], RMSEA = 0.048 (90% confidence interval = 0.001, 0.076), SRMR = 0.059, CFI = 0.96, TLI = 0.94. Fig. 1 depicts the specified model, with standardized factor loadings. Notably, Grasmick et al. Self-Control total scores exhibited a comparable loading ($|0.72|$) as compared to other purpose-built disinhibition indicators (range = 0.68 to 0.85). The loadings of domain specific factors onto the higher-order factor were also quite comparable to the model reported by Venables, Foell, et al. (2017): self-report = 0.41 (versus 0.40), task-performance = −0.62 (−0.60), and brain response = −0.74 (−0.77).

4. Discussion

The current study sought to integrate criminological and psychopathology perspectives on delinquency vis-à-vis a conceptual and empirically derived neurobehavioral model of disinhibition. Consistent with primary hypotheses, and consistent with prior published research (Pratt & Cullen, 2000; Vazsonyi et al., 2017), we found that overall scores on the Grasmick et al. (1993) self-control inventory showed robust negative associations with antisocial behavior and substance use. Additionally, we found low self-control to be associated with high levels of disinhibition assessed across multiple levels of analysis (self-reports,

(*footnote continued*)
antisocial behavior ($B = -0.10$, $p > 0.24$) when controlling for ESI-DIS in the second step. However, ESI-DIS was a significant predictor of antisocial behavior when controlling for Self-Control ($B = -0.57$, $p < 0.001$) and added incrementally to the prediction when entered in the model as evidence by a significant change in model R^2 (0.20, $p < 0.001$). A parallel pattern of findings emerged for the regression model predicting the substance use composite. Self-Control was a significant predictor of substance use in the first step ($B = -0.50$, $p < 0.001$) but was a trend level predictor ($B = -0.15$, $p = 0.056$) when controlling for ESI-DIS in the second step. However, ESI-DIS was a significant predictor of substance use when controlling for Self-Control ($B = 0.58$, $p < 0.001$) and added incrementally to the prediction when entered in the model as evidence by a significant change in model R^2 (0.21, $p < 0.001$).

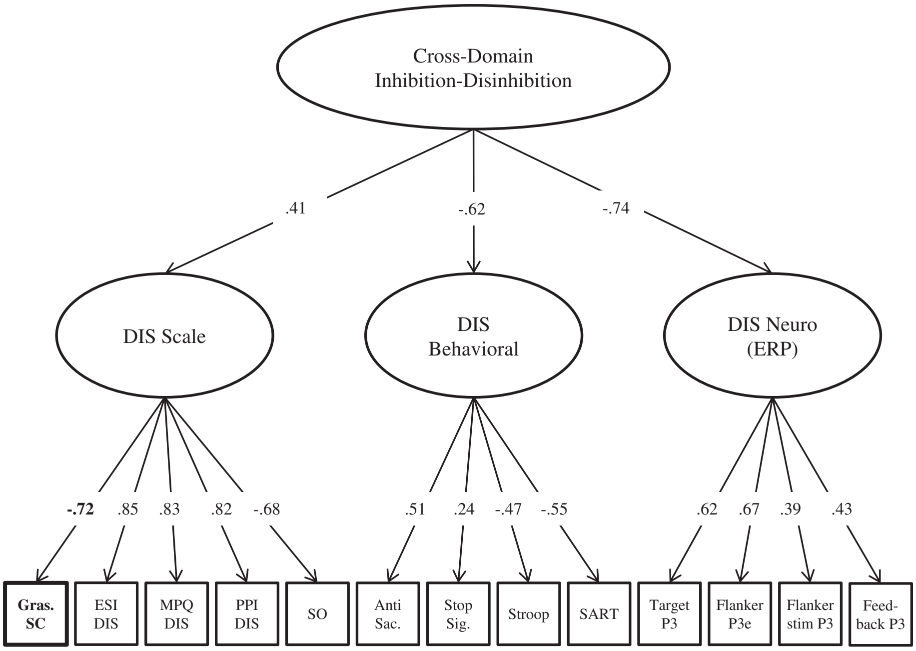

Fig. 1. Results from a three-factor with one higher-order factor confirmatory factor analytic model of disinhibition (DIS) and self-control as assessed by differing measurement domains and a biobehavioral *cross-domain* factor corresponding to the covariance across domains. Standardized parameter estimates are provided. Gras SC = Grasmick Self-Control scale; ESI-DIS = Externalizing Spectrum Inventory Disinhibition scale; MPQ-DIS = -Multidimensional Personality Questionnaire Disinhibition scale; PPI-DIS = Psychopathic Personality Inventory Disinhibition scale; SO = Gough's Socialization scale; AntiSac. = Antisaccade accuracy; Stop Signal = proactive inhibition from the Stop Signal task; Stroop = reaction time to incongruent stimuli from the Stroop task; SART = reaction time variability from the sustained attention to response task; ERP = event-related potential; Target P3 = amplitude of P3 ERP to targets in the Oddball task; Flanker P3e = amplitude of P3 ERP following errors in the Flanker task; Flanker stim. P3 = amplitude of P3 ERP to arrow stimuli in the Flanker task; and Feedback P3 = amplitude of P3 ERP to feedback cues in the pseudo-gambling task.

inhibitory control lab-task measures, and neurophysiological functioning assessed by variants of the P3 brain response measure from separate cognitive tasks). Whereas associations for total scores from the Grasmick et al. (1993) inventory were largely consistent with hypotheses, results for individual facet scales were mixed. Notably the Impulsivity and Temper scales were consistently related to delinquency and trait disinhibition across measurement domains. While the Risk Taking and Self-Centeredness scales were mostly associated with self-reported delinquency and disinhibition, they were largely unrelated to the behavioral-performance and neurophysiological domains of disinhibition. Further, the Simple Tasks and Physical Activities scales were modestly associated with self-reported disinhibition, but negligibly related to non-report factors of trait disinhibition and to antisocial and substance use outcome measures. These results are consistent with recent work (Jones, 2017) indicating that not all facets of the Grasmick et al. measure of self-control are predictive of delinquency, and future work with this scale may benefit from further refinement to maximize its predictive validity. As discussed further below, scale refinement efforts are likely to benefit from use of trait disinhibition measures and consideration of neurobehavioral-systems constructs.

We also included Grasmick et al. self-control total scores as an additional self-report indicator within a biobehavioral model of disinhibition (Venables, Foell, et al., 2017). This model specified three measurement domain specific lower order factors: self-report scale, behavioral-performance (inhibitory control task measures), and neurophysiological (variants of P3 brain response from different cognitive tasks). Covariance among the lower-order domain specific factors was expressed as a higher-order cross-domain factor reflective of inhibition mechanisms and disinhibitory traits. Results from this model indicated that self-control is a robust indicator of self-reported disinhibition (−0.72) and that its inclusion in the model did not alter other parameters such as loadings of the domain-specific factors onto the higher-order cross-domain factor. Taken together, results from the study provide compelling support for our overarching hypothesis that self-control and disinhibition are largely reflective of a common dispositional tendency towards under-controlled delinquency and poor inhibitory control.

While original conceptions of self-control emphasized environmental influences on dispositional tendencies towards criminal delinquency (cf. Gottfredson & Hirschi, 1990), more contemporary work has emphasized the role of genetic factors (Connolly & Beaver, 2014) and associated neural-mediated inhibitory mechanism (Reynolds & McCrae, 2017). Despite differing origins, this newer investigative work dovetails with psychopathology research that has emphasized the role of disinhibition as a genetically influenced disposition related to substance use and antisocial forms of deviancy (cf. Krueger et al., 2002) that relates in turn to brain indices of neuro-cognitive processing (Iacono et al., 2002; Hicks et al., 2007; Yancey et al., 2013) and executive functioning as indexed by behavioral-performance measures (Young et al., 2009; Venables, Foell, et al., 2017). As such, previous research and results from the current study suggest that self-control and disinhibition are largely isomorphic terms for a dispositional tendency towards under-controlled behavior that operates as a general liability for impulsive behavioral deviancy including acts of delinquency.

The integration of self-control into an extensive cross-domain disinhibition model, as described in this study, places the construct in a conceptual framework that opens new avenues of investigating the role of self-control in etiological accounts of criminality. Our proposed approach in anchoring self-control and disinhibition within a multi-domain of measurement framework would allow for determining the role of self-control in contributing to criminal behavior by linking these associations to brain systems and mechanisms. Available evidence suggests disinhibition reflects a genetically influenced propensity towards poor inhibitory control (Young et al., 2009), or deficiencies in the deliberate overriding of dominant or prepotent response set that is a core aspect of executive function.

Longitudinal investigations of self/other-reported self-control have highlighted its importance in predicting to differing forms of delinquency in addition to other health outcomes. In the study reported by Moffitt et al. (2011), self-control assessed in early childhood (3–5 years old) predicted delinquency (criminal offending and substance use) at age 32. However, self-control was also predictive of a wider-range of negative outcomes including reduced educational and occupational attainment, financial difficulties, and physical ailments including metabolic abnormalities, inflammatory conditions, and sexually transmitted disease. Results from the Moffitt et al. study suggests that the predictive validity of self-control was independent of other influential factors such as general intelligence and socio-economic status. The conceptualization of self-control as a gradient of individual differences offered by Moffitt et al. (2011) is consistent with the notion of disinhibition as a dispositional tendency. While studies of P3 brain response amplitude have shown consistent prospective predictions to antisocial behavior and substance use (cf. Iacono et al., 2002), other non-report measures of disinhibition (or self-control) such as behavioral-performance measures have been investigated to a lesser degree in term of predictive relations to delinquency and other negative outcomes.

Some limitations of the present study highlight future avenues of research. First, the cross-sectional design of the present study is a limitation that prevents establishing the predictive validity of our cross-domain model of disinhibition to future delinquent behavior. It will be important in future work that seeks to integrate these two complementary perspectives to utilize etiologically informative designs (twin and/or longitudinal) that permit testing causal hypotheses regarding the role of disinhibition and mechanisms of self-control that are predictive of delinquency. Notwithstanding this limitation, the current study provides compelling support for linkages between self-control and lab-task measures of inhibitory control. Given the large time and cost investments in conducting large-scale longitudinal work, research such as the present study is vital to determining the relevant candidate indicators that are likely to be fruitful predictors to future delinquency. Further, work such as the present study can serve to connect new variables of interest (e.g., task-performance or brain response measures) to existing datasets by including intersecting measures to serve as "metric bridges" (Friedman, Kern, Hampson, & Duckworth, 2014) towards harmonizing etiologically informative datasets with other datasets such as the present one that contain a rich set of disinhibition/self-control indicators.

Further studies may benefit from employing neurophysiological and brain-imaging methods to identify neural mechanisms of disinhibition and self-control. For example, Hare et al. (2009) demonstrated specific differences in brain activation between groups designated as 'self-controllers' and 'non-self-controllers'. When exercising self-control successfully in a behavioral task, self-controllers displayed significantly higher activation in the dorsolateral prefrontal cortex (DLPFC), a region that has been shown to be related to differing forms of self-control and behavior regulation (cf. Tabibnia et al., 2008; Hayashi et al., 2013; Cohen & Lieberman, 2010). In that study, DLPFC activation was generally increased for successful behavioral self-control, with higher rates for self-controllers. Further, goal-directed decisions (whether or not self-control was exercised) was strongly correlated with activation in the ventromedial prefrontal cortex (vmPFC) in this sample as well. These findings dovetail with other work by Balleine and O'Doherty (2010) demonstrating a role for vmPFC in goal-directed behavior in both humans and rodents. In order to identify potential mutual regulatory roles of both regions, these authors analyzed any task-related functional connectivity interactions between DLPFC and vmPFC in their sample and ruled out any direct modulation of vmPFC by DLPFC. Follow-up analyses suggested indirect modulation via a two-node network composed of connected mediatory areas, including the inferior frontal gyrus (IFG). Additional research is needed to further investigate the control network suggested by the findings of Balleine and O'Doherty. For example, using a neuroimaging-based self-control task, the relationship between activation in the DLPFC-IFG-vmPFC network described in Hare et al. (2009) and the self-report disinhibition and self-control measures described here could be examined in a way that would permit further inferences regarding the neural basis of behavioral inhibition. Additionally, the same neural network and the same trait personality measures could be used in the context of behavioral self-control paradigms, such as the stop-signal or antisaccade tasks, which have been used successfully in neuroimaging settings (cf. Chevrier et al., 2007; Ford, Goltz, Brown, & Everling, 2005) and which are key indicators in the executive function model proposed by Miyake & Friedman (2012). As an example of research investigating neural and psychological-trait predictors of delinquency, Meldrum et al. (in press) recently demonstrated that reduced activation of the anterior cingulate cortex (ACC), a region known to be integral for cognitive control (cf. Braver et al., 2001), was associated with delinquency. Further, low self-control mediated the association between this brain response elicited in an inhibitory control task and measures of delinquent behavior.

In summary, results from the current study demonstrate a strong link between the criminological concept of self-control and the psychopathology construct of trait disinhibition as related to differing forms of delinquency. Deficits in self-control were associated with biobehavioral measures (behavioral performance on inhibitory control tasks and brain response measures) and was seamlessly integrated within a broader nomological network of disinhibition that spans multiple levels of analysis. Research in both the criminology and psychopathology realms could benefit from a multi-domain informed concept of trait disinhibition and self-control. These findings lend further support to the overall cross-domain model of disinhibition to assess and provide a mechanistic account of criminology and psychopathology perspectives on behavioral deviancy.

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References

Arneklev, B. J., Grasmick, H. G., & Bursik, R. J. (1999). Evaluating the dimensionality and invariance of "low self-control". *Journal of Quantitative Criminology, 15*(3), 307–331.

Balleine, B. W., & O'doherty, J. P. (2010). Human and rodent homologies in action control: Corticostriatal determinants of goal-directed and habitual action. *Neuropsychopharmacology, 35*(1), 48–69.

Barkley, R. A. (1997). *ADHD and the nature of self-control.* New York: Guilford.

Barlow, H. D. (1991). Explaining crimes as analogous acts, or the unrestrained will grab at pleasure wherever they can. *Journal of Criminal Law and Criminology, 82*, 211–253.

Beaver, K. M., DeLisi, M., Mears, D. P., & Stewart, E. (2009). Low self-control and contact with the criminal justice system in a nationally representative sample of males. *Justice Quarterly, 26*(4), 695–715.

Beaver, K. M., Wright, J. P., & DeLisi, M. (2007). Self-control as an executive function: Reformulating Gottfredson and Hirschi's parental socialization thesis. *Criminal Justice & Behavior, 34*(10), 1345–1361.

Beaver, K. M., Wright, J. P., DeLisi, M., & Vaughn, M. G. (2008). Genetic influences on the stability of low self-control: Results from a longitudinal sample of twins. *Journal of Criminal Justice, 36*(6), 478–485.

Begleiter, H., Porjesz, B., Bihari, B., & Kissin, B. (1984). Event-related brain potentials in boys at risk for alcoholism. *Science, 225*(4669), 1493–1496.

Braver, T. S., Barch, D. M., Gray, J. R., Molfese, D. L., & Synder, A. (2001). Anterior cingulate cortex and response conflict: Effects of frequency, inhibition, and errors. *Cerebral Cortex, 11*, 825–836.

Bress, J. N., Smith, E., Foti, D., Klein, D. N., & Hajcak, G. (2012). Neural response to reward and depressive symptoms in late childhood to early adolescence. *Biological Psychology, 89*, 156–162.

Brislin, S. J., Drislane, L. E., Smith, S. T., Edens, J. F., & Patrick, C. J. (2015). Development and validation of triarchic psychopathy scales from the Multidimensional Personality Questionnaire. *Psychological Assessment, 27*(3), 838–851.

Brislin, S. J., Venables, N. C., Drislane, L. E., Blonigen, D. M., Iacono, W. G., Tellegen, A., ... Patrick, C. J. (2017). Further validation of triarchic psychopathy scales from the multidimensional personality questionnaire: Setting the stage for large-sample etiological studies. *Assessment, 24*(5), 575–590.

Chevrier, A. D., Noseworthy, M. D., & Schachar, R. (2007). Dissociation of response inhibition and performance monitoring in the stop signal task using event-related fMRI. *Human Brain Mapping, 28*(12), 1347–1358.

Cohen, J. R., & Lieberman, M. D. (2010). The common neural basis of exerting self-control in multiple domains. *Self-control in Society, Mind, and Brain, 1*, 141–162.

Connolly, E. J., & Beaver, K. M. (2014). Examining the genetic and environmental influences on self-control and delinquency: Results from a genetically informative

analysis of sibling pairs. *Journal of Interpersonal Violence, 29*(4), 707–735.
DeLisi, M., Beaver, K. M., Wright, J. P., & Vaughn, M. G. (2008). The etiology of criminal onset: The enduring salience of nature and nurture. *Journal of Criminal Justice, 36*(3), 217–223.
DeLisi, M., Hochstetler, A., & Murphy, D. S. (2003). Self-control behind bars: A validation study of the Grasmick et al. scale. *Justice Quarterly, 20*(2), 241–263.
DeLisi, M., & Vaughn, M. G. (2008). The Gottfredson–Hirschi critiques revisited: Reconciling self-control theory, criminal careers, and career criminals. *International Journal of Offender Therapy and Comparative Criminology, 52*(5), 520–537.
Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics, 16*, 143–149.
Ford, K. A., Goltz, H. C., Brown, M. R., & Everling, S. (2005). Neural processes associated with antisaccade task performance investigated with event-related FMRI. *Journal of Neurophysiology, 94*(1), 429–440.
Foti, D., & Hajcak, G. (2009). Depression and reduced sensitivity to non-rewards versus rewards: Evidence from event-related potentials. *Biological Psychology, 81*(1), 1–8.
Friedman, H. S., Kern, M. L., Hampson, S. E., & Duckworth, A. L. (2014). A new life-span approach to conscientiousness and health: Combining the pieces of the causal puzzle. *Developmental Psychology, 50*(5), 1377–1389.
Garavan, H., Ross, T. J., & Stein, E. A. (1999). Right hemispheric dominance of inhibitory control: An event-related functional MRI study. *Proceedings of the National Academy of Sciences of the United States of America, 96*, 8301–8306.
Gottfredson, M. R., & Hirschi, T. (1990). *A general theory of crime.* Stanford: Stanford University Press.
Gough, H. G. (1960). Theory and measurement of socialization. *Journal of Consulting Psychology, 24*, 23–40.
Grasmick, H. G., Tittle, C. R., Bursik, R. J., Jr., & Arneklev, B. J. (1993). Testing the core empirical implications of Gottfredson and Hirschi's general theory of crime. *Journal of Research in Crime and Delinquency, 30*(1), 5–29.
Hall, J. R., Bernat, E. M., & Patrick, C. J. (2007). Externalizing psychopathology and the error-related negativity. *Psychological Science, 18*, 326–333.
Hall, J. R., Drislane, L. E., Patrick, C. J., Morano, M., Lilienfeld, S. O., & Poythress, N. G. (2014). Development and validation of Triarchic construct scales from the psychopathic personality inventory. *Psychological Assessment, 26*(2), 447.
Hallett, P. E. (1978). Primary and secondary saccades to goals defined by instructions. *Vision Research, 18*(10), 1279–1296.
Hare, T. A., Camerer, C. F., & Rangel, A. (2009). Self-control in decision-making involves modulation of the vmPFC valuation system. *Science, 324*(5927), 646–648.
Harris, J. R. (1998). *The nurture assumption: Why children turn out the way they do.* New York: The Free Press.
Hay, C., & Forrest, W. (2008). Self-control theory and the concept of opportunity: The case for a more systematic union. *Criminology, 46*(4), 1039–1072.
Hayashi, T., Ko, J. H., Strafella, A. P., & Dagher, A. (2013). Dorsolateral prefrontal and orbitofrontal cortex interactions during self-control of cigarette craving. *Proceedings of the National Academy of Sciences, 110*(11), 4422–4427.
Hicks, B. M., Bernat, E. M., Malone, S. M., Iacono, W. G., Patrick, C. J., Krueger, R. F., & McGue, M. (2007). Genes mediate the association between P3 amplitude and externalizing disorders. *Psychophysiology, 44*, 98–105.
Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1–55.
Iacono, W., Carlson, S., Malone, S., & McGue, M. (2002). P3 event-related potential amplitude and the risk for disinhibitory disorders in adolescent boys. *Archives of General Psychiatry, 59*, 750–757.
Iacono, W. G., Malone, S. M., & McGue, M. (2008). Behavioral disinhibition and the development of early-onset addiction: Common and specific influences. *Annual Review of Clinical Psychoology, 4*, 325–348.
Jones, S. (2017). Does choice of measure matter? Assessing the similarities and differences among self-control scales. *Journal of Criminal Justice, 50*, 78–85.
Krueger, R. F. (1999). The structure of common mental disorders. *Archives of General Psychiatry, 56*, 921–926.
Krueger, R. F., Hicks, B., Patrick, C. J., Carlson, S., Iacono, W. G., & McGue, M. (2002). Etiologic connections among substance dependence, antisocial behavior, and personality: Modeling the externalizing spectrum. *Journal of Abnormal Psychology, 111*, 411–424.
Krueger, R. F., Markon, K. E., Patrick, C. J., Benning, S. D., & Kramer, M. D. (2007). Linking antisocial behavior, substance use, and personality: An integrative quantitative model of the adult externalizing spectrum. *Journal of Abnormal Psychology, 116*(4), 645–666.
Lilienfeld, S. O., & Andrews, B. P. (1996). Development and preliminary validation of a self-report measure of psychopathic personality traits in noncriminal population. *Journal of Personality Assessment, 66*(3), 488–524.
Longshore, D., Rand, S. T., & Stein, J. A. (1996). Self-control in a criminal sample: An examination of construct validity. *Criminology, 34*(2), 209–228.
Longshore, D., & Turner, S. (1998). Self-control and criminal opportunity cross-sectional test of the general theory of crime. *Criminal Justice and Behavior, 25*(1), 81–98.
McCord, W., McCord, J., & Zola, I. K. (1959). *Origins of crime: a new evaluation of the Cambridge-Somerville Youth Study.* New York, NY: Columbia University Press.
McVay, J. C., & Kane, M. J. (2009). Conducting the train of thought: Working memory capacity, goal neglect, and mind wandering in an executive-control task. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 35*(1), 196–204.
McVay, J. C., & Kane, M. J. (2012). Why does working memory capacity predict variation in reading comprehension? On the influence of mind wandering and executive attention. *Journal of Experimental Psychology: General, 141*(2), 302–320.
Meldrum, R. C., Trucco, E. M., Cope, L. M., Zucker, R. A., & Heitzeg, M. M. (in press). Brain activity, low self-control, and delinquency: An fMRI study of at-risk adolescents. *Journal of Criminal Justice*. doi: 10.1016/j.jcrimjus.2017.07.007.
Miller, J. D., & Lynam, D. R. (2003). Psychopathy and the five-factor model of personality: A replication and extension. *Journal of Personality Assessment, 81*, 168–178.
Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychological Science, 21*(1), 8–14.
Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology, 41*, 49–100.
Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H., & Sears, M. R. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences, 108*(7), 2693–2698.
Muthén, L. K., & Muthén, B. O. (1998-2015). *Mplus user's guide* (Seventh Edition). Los Angeles, CA: Muthén & Muthén.
Nelson, L. D., Patrick, C. J., & Bernat, E. M. (2011). Operationalizing proneness to externalizing psychopathology as a multivariate psychophysiological phenotype. *Psychophysiology, 48*, 64–72.
Nye, F. I. (1958). *Family relationships and delinquent behavior.* New York, NY: Wiley24–31.
Patrick, C. J., Bernat, E., Malone, S. M., Iacono, W. G., Krueger, R. F., & McGue, M. K. (2006). P300 amplitude as an indicator of externalizing in adolescent males. *Psychophysiology, 43*, 84–92.
Patrick, C. J., Curtin, J. J., & Tellegen, A. (2002). Development and validation of a brief form of the multidimensional personality questionnaire. *Psychological Assessment, 14*, 150–163.
Patrick, C. J., Kramer, M. D., Krueger, R. F., & Markon, K. E. (2013). Optimizing efficiency of psychopathology assessment through quantitative modeling: Development of a brief form of the Externalizing Spectrum Inventory. *Psychological Assessment, 25*, 1332–1348.
Patrick, C. J., Venables, N. C., Yancey, J. R., Hicks, B. M., Nelson, L. D., & Kramer, M. D. (2013). A construct-network approach to bridging diagnostic and physiological domains: Application to assessment of externalizing psychopathology. *Journal of Abnormal Psychology, 122*, 902–916.
Polich, J. (2007). Updating the P300: An integrative theory of P3a and P3b. *Clinical Neurophysiology, 118*, 2128–2148.
Pratt, T. C., & Cullen, F. T. (2000). The empirical status of Gottfredson and Hirschi's general theory of crime: A meta-analysis. *Criminology, 38*(3), 931–964.
Reynolds, J. J., & McCrea, S. M. (2017). Criminal behavior and self-control: Using the dual component theory of inhibition regulation to advance self-control and crime research. *Current Psychology,* 1–10.
Slade, T. I. M., & Watson, D. (2006). The structure of common DSM-IV and ICD-10 mental disorders in the Australian general population. *Psychological Medicine, 36*(11), 1593–1600.
Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643–662.
Tabibnia, G., Satpute, A. B., & Lieberman, M. D. (2008). The sunny side of fairness preference for fairness activates reward circuitry (and disregarding unfairness activates self-control circuitry). *Psychological Science, 19*(4), 339–347.
Vazsonyi, A. T., Mikuška, J., & Kelley, E. L. (2017). It's time: A meta-analysis on the self-control-deviance link. *Journal of Criminal Justice, 48*, 48–63.
Venables, N. C. (2016). *Toward a cross-domain conception of inhibitory control capacity as relevant to impulse control problems.* Doctoral dissertation*Available from ProQuest Dissertations and Theses A&I* (1873048862).
Venables, N. C., Foell, J., Yancey, J. R., Kane, M. J., Engle, R. W., & Patrick, C. J. (2017). *Cross-domain assessment of inhibitory control capacity as relevant to clinical problems and adaptive performance.* (Manuscript submitted for publication).
Venables, N. C., Patrick, C. J., Hall, J. R., & Bernat, E. M. (2011). Clarifying relations between dispositional aggression and brain potential response: Overlapping and distinct contributions of impulsivity and stress reactivity. *Biological Psychology, 86*, 279–288.
Venables, N. C., Yancey, J. R., Kramer, M. D., Hicks, B. M., Nelson, L. D., Strickland, C. M., ... Patrick, C. J. (2017). Evidence of a prominent genetic basis for associations between psychoneurometric traits and common mental disorders. *International Journal of Psychophysiology, 115*, 4–12.
Verbruggen, F., & Logan, G. D. (2009). Proactive adjustments of response strategies in the stop-signal paradigm. *Journal of Experimental Psychology: Human Perception and Performance, 35*(3), 835–854.
Verbruggen, F., Logan, G. D., & Stevens, M. A. (2008). STOP-IT: Windows executable software for the stop-signal paradigm. *Behavior Research Methods, 40*, 479–483.
Vollebergh, W. A., Iedema, J., Bijl, R. V., de Graaf, R., Smit, F., & Ormel, J. (2001). The structure and stability of common mental disorders: The NEMESIS study. *Archives of General Psychiatry, 58*(6), 597–603.
Weinberg, A., Kotov, R., & Proudfit, G. H. (2015). Neural indicators of error processing in generalized anxiety disorder, obsessive-compulsive disorder, and major depressive disorder. *Journal of Abnormal Psychology, 124*(1), 172–185.
Wright, J. P., & Beaver, K. M. (2005). Do parents matter in creating self-control in their children? A genetically informed test of Gottfredson and Hirschi's theory of low self-control. *Criminology, 43*(4), 1169–1202.
Yancey, J. R., Venables, N. C., Hicks, B. M., & Patrick, C. J. (2013). Evidence for a heritable brain basis to deviance-promoting deficits in self-control. *Journal of Criminal Justice, 41*, 309–317.
Young, S. E., Friedman, N. P., Miyake, A., Willcutt, E. G., Corley, R. P., Haberstick, B. C., & Hewitt, J. K. (2009). Behavioral disinhibition: Liability for externalizing spectrum disorders and its genetic and environmental relation to response inhibition across adolescence. *Journal of Abnormal Psychology, 118*, 117–130.
Young, S. E., Stallings, M. C., Corley, R. P., Krauter, K. S., & Hewitt, J. K. (2000). Genetic and environmental influences on behavioral disinhibition. *American Journal of Medical Genetics, 96*, 684–695.